Robert L. Bates

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THE ASSOCIATION OF GEOLOGY TEACHERS

The ASSOCIATION OF GEOLOGY TEACHERS was founded in the Middle West in May, 1938. In November, 1951, it was organized as a national association, under which there are at present five organized regional sections: Central, East Central, Eastern, New England, and Far Western. A Southeastern Section will be organized in the near future. An annual meeting of the national association is normally held in the fall, and sectional meetings are held in the spring.

The purpose of the Association, as stated in its Constitution, is "to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public."

Anyone concerned with geological education, formal or informal and at any age level, is invited to apply for membership. *Inquiries should be addressed to the national secretary:*

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JOURNAL OF GEOLOGICAL EDUCATION
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THE AGT AND THE AGI

Chester R. Longwell*
Yale University

Last winter the Association of Geology Teachers asked to be admitted as a member of the American Geological Institute. At a full meeting of the AGI Board of Directors held at St. Louis in April, 1954, unanimous approval of the request for admission was registered, and the matter was referred to the twelve parent societies. Final approval by the member societies was received July 6, 1954, and AGT is now a member of the Institute. Thus the AGT is distinguished as the "lucky thirteenth" in the membership of AGI. We recall that our country began its proud career with the union of thirteen independent colonies which came to realize the advantages of standing together.

The AGT, a vigorous organism only a few years old, has more than justified the expectations of its founders. Starting modestly in the Midwest, it has expanded east, west, north, and south, and now is truly national in scope. Teachers are thoughtful folk and have been quick to realize the advantages of union. It is significant that this newcomer among geological societies has voluntarily thrown its support to the American Geological Institute, which seeks to unify the efforts of all groups and individuals devoted to Earth Science. Is this expression of confidence from the teachers justified? What exactly is the AGI, and what are the prospects that it will improve the status of all geology?

Near the start of the Great War—all of thirteen years ago—many of us were stirred by an article in which Carey Croneis focussed attention on the disunity and lack of direction in our science and profession. He decried the continued subdivision along specialistic lines, without a counter balance and stabilizing influence in an overall organization. In the war years that followed, the truth of this diagnosis became acutely evident. Geology was failing to get the recognition it deserved because we were not pulling together. During the war a concerted effort was begun to remedy this situation. Representatives of several societies met, first in New York, later in Washington, and after many days of discussion and study they drew up a plan for an American Geological Institute, with Articles of Organization.

*For the year 1954 the author of this paper is president of the American Geological Institute.

But important matters had to be resolved before the organization laid out on paper could actually function. Like the original colonies, the several societies had to be assured that their cherished freedoms would not be imperiled by the proposed union. Might the AGI grow into an incubus, a tyrannical overlord? These apprehensions gradually subsided, but a more practical difficulty came to the fore. Where would the proposed Institute have its quarters, and how would it be financed? In the spring of 1947 the Chairman of the National Research Council, Detlov Bronk, offered quarters and other facilities for the Institute in the National Academy Building in Washington, D. C. The more opulent geological societies contributed funds for the first year's budget, and in November, 1948, the Institute was launched with an Executive Director and a modest secretarial force. It is now in its sixth year of operation.

How has the infant fared, and what has it done to justify the hopes of its parents? Frankly, not all of the going has been easy, and honest doubts have been expressed as to whether the hopes were well founded. The most immediate and constant problem has been one of a home, with enough bread and butter. Employees and facilities mean an annual budget, which in turn requires an income. Much credit is due the National Research Council, which from the start has supplied housing and has helped materially in meeting other running expenses. Additional chief sources of funds have been annual contributions from the Geological Society of America and the American Association of Petroleum Geologists; smaller sums from other member societies; donations from a number of oil companies, which are carried as associates of AGI; and gifts from individuals. The Institute has supplemented these sources, in a modest way, from sales of publications it has issued. But clearly the financial situation of the Institute is precarious, subject to change for the worse on short notice. Onset of a depression might take away all donations from private companies; one of the chief supporting societies might at any time decide that it has done its share. There is not, and under present conditions cannot be, any pension plan to assure an able director the security he may have in other attractive positions. And without high-caliber direction, how can our experiment in union of the Earth Sciences hope to wax strong or even to survive?

A paragon among institutes of science is the American Institute of Physics, which was founded primarily to solve the publication problems of the several physics journals. These problems have been effectively resolved, and the resultant savings have placed the Institute on a sound financial basis. The situation among the Earth Sciences is very different; their principal journals are self-sufficient, and we see no immediate prospect

that the several societies will consider pooling their publication activities for the common good. On what basis, then, can the Earth Sciences expect to have a union that will succeed both spiritually and financially?

Not until this year did we have any adequate basis for estimating the number of Earth Scientists in this country. Generous aid from the National Science Foundation has made possible a systematic register, which though not yet complete is in an advanced stage. Results now in hand indicate that our geologists and geophysicists combined total about 20,000. The annual budget of the American Geological Institute is about $20,000. Can we afford to contribute one dollar each per year to keep the AGI going? That, of course, depends on the value of its services to each and all of us. What has AGI done, and what are its potentialities for the future?

(1) Geology is a mysterious subject to the average citizen. Most high-school students know nothing about it, and only a small percentage of college freshmen have any idea of geology as a cultural subject or as a possible field for a career. The first director of AGI, David M. Delo, saw in this situation an outstanding weakness of our profession. He sponsored and helped prepare several informative pamphlets and booklets which were widely distributed among laymen, particularly in high schools. This valuable service is only a beginning; the Institute should have a continuing program for "spreading the gospel" of Earth Science.

(2) Information about departments of geology in this country and Canada—names and addresses of schools that have departments, faculty members in each, courses and degrees offered—was nebulous and unorganized until the Institute prepared and published a complete directory. This valuable work of reference is being kept up to date and is a very practical help to geology teachers.

(3) A directory that is even more widely useful was published by the Institute this year; it lists the names and addresses of all American geologists and geophysicists who have been recorded in the register prepared with the aid of the National Science Foundation. Extending this directory and keeping it up to date will be a continuing project.

(4) Although each of our societies has a journal, distributed among its members, there was no means of printed communication among all Earth Scientists until the AGI *Newsletter* was launched in 1948. For nearly six years this publication has been on a subscription basis and has reached only one geologist in ten. Starting in September of this year, the "geologists' newspaper" is being sent, free of charge, to every member of each parent organization. We hope that advertising will eventually cover most or all of the cost, thus placing this news service on a permanent basis.

Here is an organ with enormous potentiality for good. Through it geologists can present their views, make known their wants, learn much about their fellows from whom they have been in large part isolated. Already this paper carries a sizable list of inquiries from job seekers and employers, and eventually it may play a large part in a placement service for geologists. Even more important, it should help weave a bond of brotherhood among the varied kinds of Earth Scientists and so lead to a more perfect union.

(5) Our literature becomes increasingly voluminous and technical, and dispersed through many journals, some not readily available. The average geologist's only hope of keeping reasonably abreast of publications in his field lies in a convenient assemblage of good abstracts. Realizing this, officers of AGI have begun a systematic publication of *Geological Abstracts*, with the hope that nearly complete coverage may be achieved and, incidentally, that the average standard of abstract writing may be raised.

(6) The technical vocabulary of the Earth Sciences is formidable. J.V. Howell conceived the ambitious plan of preparing a comprehensive glossary of geologic terms and asked the Institute to sponsor the project, which concerns all branches of geology and geophysics. Preparing and publishing this work is a formidable task,requiring considerable financial aid from the National Science Foundation. The Institute exercises general supervision only; the actual work is being done by staffs outside the Institute office.

(7) Since the Second World War, scientists and statesmen have been much concerned about the training and conservation of our scientific manpower. In that war emphasis was placed on equality of service, in such degree that training of scientists was sadly neglected. Now we have in Washington a Scientific Manpower Commission, made up of representatives from the several major fields of science. Members representing the Earth Sciences are named by the AGI. Clearly, no one of our several societies could presume or be allowed to take the initiative in this critical matter; we must have a spokesman for our entire field, and the AGI is our ideal spokesman. The Scientific Manpower Commission is consulted by top civilian and military officials, and its performance is bringing about a wiser and more effective national policy in the training and use of scientists.If the AGI could perform no function other than this national representation of the Earth Sciences, its continuance would be more than justified.

But some readers may exclaim,"Why all these arguments in this space? If the AGT were not already convinced that the AGI is worthy, we would not have applied for membership in the Institute."This article is presented

to the teachers, with the object not to convert them but to enlist their help in combatting a rising opposition in other quarters. This opposition, which we believe has grown from agnorance of the facts, argues as follows: (1) All useful projects carried out by AGI could have been undertaken just as well through one or another of the parent societies. (2) The AGI is an added and unnecessary expense and in all likelihood will grow continuously more expensive, placing a burden on the member societies. (3) One of the larger parent groups—AAPG or GSA—could assume the role of national spokesman for all Earth Science. (4) The AGI has its headquarters in Washington, in close association with units of the federal government. This government already exerts an inordinate influence over our lives and affairs.

Let us look at these points briefly.

(1) Theoretically some individuals or societies might have done some of the things credited to AGI. Actually these projects waited until the union of societies was effected. The record of AGI demonstrates pretty conclusively the real need for an organization that focusses on the problems of all Earth Science.

(2) Expense is of course a matter of concern to us all. We cannot afford to allow expansion of the AGI quarters and staff to care for unlimited operations. The present policy is to undertake a project only if a member society is willing and able to carry it through with its existing facilities; or if a special grant, from the National Science Foundation or a similar agency, makes it possible to set up an operating unit for the particular task.

(3) Is it likely the original colonies would have agreed to let Massachusetts or New York or Virginia provide federal government for the entire group of thirteen? Human nature being what it is, the suggestion that one or another of our societies take over the leading role is futile talk.

(4) The aversion to Washington as a home for AGI is astonishing. Even if we should admit a dislike for some aspects of the federal government, can we avoid dealing with it? Shall we go hide our heads in the sand instead of keeping ourselves informed about government actions that affect us closely? And can we be better informed anywhere than in Washington, where we can have direct contact with government offices and officials? The National Research Council is in no sense a part of the federal government, but it is an agency through which we can learn about government procedures and intentions that will affect us closely. And since governments are human affairs, we may, with proper contacts, exert some influence in fashioning important decisions. The Scientific Manpower Commission, in which we have a voice, is consulted and listened to by high gov-

ernment officials. Washington is the one logical home for an organization that is to represent all Earth Science.

The AGI is new, and as yet it has made no real contact with large numbers of individuals in the member societies. We need an educational campaign that will reach to the grassroots. Widespread circulation of the improved *Newsletter* should be effective in clearing away much of the misinformation about our Institute. And we are depending on members of the AGT to use their missionary abilities in this campaign to better the lot of Earth Science.

How can we assure AGI a permanently sound financial basis? One possibility is to have the parent societies assess their members a dollar each per year. Each member will get much more than a dollar's worth in the issues of the *Newsletter.* In addition, he will feel some direct responsibility for the support of the Institute and will have a personal interest in its program and its welfare.

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A TECHNIQUE OF TEACHING FIELD GEOLOGY*

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Most geologists recognize the advantages of incorporating a program of field courses in the normal undergraduate curriculum. With the pressure from industry and the national emergency placed directly upon our graduating young men, it has become apparent that the educator these days must do an even better job than has been done in the past. In addition there is a perpetual increase in the volume of geological material to be mastered by students to enable them to keep pace with expanding geological industries. Unfortunately the time available to young men for college study has not increased. Still we must produce graduates with greater competence. This condition places the burden upon the educator, who must do more in less time. Teaching techniques which will enable him to accomplish the task should be thoroughly investigated and tested in the classroom for best results. More and better geology can be taught the undergraduate provided we are willing to continually revise and improve our methods of teaching so as to best exploit the fantastic potential of the young mind. As soon as we begin to under-estimate the capabilities of our students, we have lost the battle.

The value of field courses to the undergraduate is immeasurable. It might be advisable first to ask ourselves, "What do we want our field courses to accomplish?" Obviously we cannot make experienced field men out of our students in the short time they are with us, no matter how much rock we show them. But we can help them to make the most out of their experience, while they are in school and after they leave. The actual measure of competence in a good field man is not given in terms of years of experience but in terms of what that experience has done to his powers of thought. If we can train students to appreciate as well as to understand, we shall have cleared the first hurdle in a much shortened race.

Every college, large or small, is surrounded by a completely equipped modern laboratory which is unique to that institution and supplied without appreciable cost. It is well for us to reflect occasionally on Amos Eaton, who continually employed his field workshop to demonstrate what could

*Presented on April 3, 1954, at the fourth annual meeting of the Eastern Section of the Association of Geology Teachers, at Rutgers University, New Brunswick, New Jersey.

not possibly be shown in any other way. His technique of learning by doing is worthy of everyone's attention. However, in the education of undergraduates there must be a proper balance between "free thought" and "disciplined thought." Otherwise we have leaned over too far toward "progressive" education and will soon find ourselves barking up our own tree. Field courses contribute to this balance nicely, provided we have continually as the goal the development of the student's capacity to improve himself by his own experience. In this respect the manner in which the field is presented is highly important. The "guided tour" type of trip is fine at the lower levels of physical and historical geology but probably it should be discouraged after this point. Equally undesirable is the "let 'em loose" variety, for it promotes too much free thought on the student's part before he is mature enough for it emotionally or geologically.

In addition, it is essential that other talents be developed concurrently with the field work. In fact, at Rensselaer the first term of the field program does not contain any field work at all. This six-contact-hour course is taken in the second term of the sophomore year, after physical geology and concurrently with historical and structural geology. The freshman year is common for all departments at the Institute and contains no geology. The student does not seem ready, on the sophomore level, for original field work, and it would waste his time to require it of him. He must first learn geomorphology and physiography and their relations to the problems of geology. This is done through an intensive study of topographic maps, at first to show the men what the surface of the ground can look like. Then after four or five weeks the students are gradually required to assemble all of the ideas they have been accumulating and put them into a form which is useful in evaluating the geologic character and history of a larger region. The topographic map work is concluded after half the term has gone by. Lobeck's *Geomorphology* is used as a text up to this point. The emphasis then shifts to regional relationships. Geologic maps are studied, and Fenneman's *Physiography of Eastern United States* is used as a reference text. The geologic folios and the state maps are particularly useful. Plenty of practice is provided in the interpretation of both topographic and geologic maps, but the important thing for us to remember is, "Don't stop here." The goal is to develop reasoning on the students' part and to keep such reasoning under control.

It is also essential that the student develop the talent of expressing himself in correct geological English. This begins on the sophomore level, when he is given the opportunity both to read and write good descriptions and interpretations of the areas with which he is working. By the time the

regional picture is presented to him in the last half of the term, the student has progressed far enough in historical and structural geology to have a fair command of the nomenclature. It is highly important that students be provided at this time with some means of organizing the vast mass of material to which they are being exposed into something tangible and relevant. Their geology has more meaning if such an outlet is provided. This is the stage at which the students' attitudes toward geology are being formed, and it is most important that this transition period be handled skillfully on our part. Students must certainly have a grasp of the science up through this point if they are to develop what we might call the "field dimension."

The development of the "field dimension" is the object of the second field course, which is again six contact hours, given in the fall of the junior year concurrently with mineralogy and stratigraphy. The methods of surveying and instrumentation are given at the beginning of the fall term. This takes about two weeks, in which a small plane-table survey is conducted and augmented by the usual types of instrument work. By the end of this time the men have been acquainted with sediments and rocks in stratigraphy and are ready to begin a field problem using this work. After a preliminary indoctrination the class is split up into three or four groups and assigned adjacent areas nearby to map and describe. This work usually lasts until bad weather sets in. The problem is so arranged that no one party can completely solve it without the contributions of the others. There are briefing sessions once a week to inform the parties what each has done and where the problem goes from there. By using this technique everyone is obliged to contribute, and each man develops his power of verbal expression of technical material. The instructor guides the work so that it can be concluded, and a careful control is kept on the parties lest they get off the track. This method is advantageous in that it is neither the "guided tour" nor the "let 'em loose" type. It is essential that the balance between these extremes be maintained if the student is to learn to think efficiently for himself. At the end of the period of field work a report is prepared as the result of the class effort. Data and maps are available for everyone's use, and the write-up is kept formal and accords with the format of professional papers.

At the close of this exercise the class begins its study of the area of the summer field camp. This work continues for the rest of the term, for about a month or six weeks. Soil maps, aerial photographs, topographic and geologic maps are used in combination to introduce the student to the area of his major summer problem. A report is prepared at the end of this

study also, emphasizing the smaller physiographic divisions and the regional aspects of the geology of the area.

The third and final field course is the summer camp, which occupies the month of June following the junior year. By this time the student is thoroughly familiar with the geography of the region and knows to some extent the type of geology he will encounter. The methods of survey have been covered, and presumably the men have had enough experience in writing and talking geology so that they are now able to promote their best efforts in the field. The area of the camp comprises the outcropping belt of the upper Silurian and lower Devonian limestones from Indian Ladder, southwest of Albany, south along the Hudson River to Kingston. A structural, lithologic, and faunal analysis is made of this area of the Helderberg Mountains. Additional work is done on the Hamilton and the clastics of the lower Silurian south of Kingston. At the northern end of the outcrop near Albany the rocks are well exposed and are nearly flat-lying. To the south the structure becomes complicated with considerable folding and faulting. There are good exposures all along the Hudson River Front for a distance of about 60 miles. Local problems of structure are abundant, and because the workable section is only 300 feet thick exercises in stratigraphic correlation and facies changes are easy to develop. Study of bio- and litho-facies changes in the Manlius limestone offers an especially nice problem and demonstrates this part of stratigraphic field work very well. The camp is mobile, consisting of tents, and provides ample opportunity for the student to learn how to care for a camp and himself while in the field. In many respects this training is just as important as the geologic work. A final report, submitted at the close of the summer work, amounts to a batchelor's thesis in geology.

The question might be asked, "Why do we employ an area in the northeast, where exposures are far from continuous and where we do not have a particularly varied geologic province?" The answer is simply this. It does not seem to make much difference what you show students in the field. It is the manner in which they are taught that is important. A field camp can be run in an igneous, metamorphic, or glacial area just as well. It does not have to show everything. Since time is limited in undergraduate curricula it is essential that students be brought to geological maturity as quickly as possible. This requires a careful scrutiny of our methods of teaching rather than the placing of the burden entirely on the student. A program of courses in field instruction which promotes a better understanding of the relationships of the geological sciences can be profitably included in the undergraduate curriculum.

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SPACE REQUIREMENTS FOR A SMALL-COLLEGE GEOLOGY DEPARTMENT*

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This paper is based upon the results of a survey recently made by means of a questionnaire sent to 23 liberal arts colleges in the east and middle west, to obtain data pertinent to planning space needs for the geology department in the expansion program of Harpur College. Harpur, established in 1948 as a four-year extension college of Syracuse University and taken into the New York State University system in 1950, has been housed in temporary structures since its inception. Land for a new campus is being purchased, and preliminary building plans are under way for a co-educational college of approximately 1200 students. Each member of the faculty has been asked to state the needs of his department, although it is not known to what extent the state will comply with these requests. In support of my request for geology space, I asked for information from fellow geologists in other schools. The purpose of this paper is to share this information with other geology teachers, that they may learn how "average" their departments actually are.

In this survey, schools with enrollment between 500 and 2000 were canvassed. Single-sex as well as co-educational institutions were included. The following information was requested: college enrollment; type of school; number of students taking elementary geology; number of geology majors; number on geology staff; departments sharing the building with geology; the amount of floor space (square feet) devoted to geology; the number and types of laboratory rooms; whether or not there is a geology museum, a department library, a department secretary, laboratory facilities for faculty research.

The following discussion is based upon the survey and includes the writer's own comments as well as those of the various respondents.

The number of students taking elementary geology in these 23 schools ranges from 23 to 300, with the average being 106.6. The number of under-

*This paper was presented on April 4, 1953, at the third annual meeting of the Eastern Section and the first annual meeting of the New England Section of the Association of Geology Teachers (joint session), at Rensselaer Polytechnic Institute, Troy, New York. After the author's death on December 20, 1953, his wife, acting at the editor's request, submitted the manuscript for publication in this journal.

graduate geology majors ranges from 4 to 40, with the average being 16.5. Thus the average ratio of elementary students to majors is 6.45 to 1.

The following table, based on reported figures for elementary geology students and majors, shows what might be called the "major potential" from elementary geology classes at small liberal arts colleges. A division has been made because it is realized that in some schools majors are listed from the junior and senior years only, whereas in other schools sophomores are included. The adjusted ratios are based upon the assumption that half of the schools reported junior and senior majors only and half included sophomores.

TABLE I—RATIO OF ELEMENTARY GEOLOGY STUDENTS TO MAJORS

Type of School and Number Surveyed	Average No. in Elementary Classes	Average No. of Majors	Potential Major Ratio I [a]	Potential Major Ratio II[b]	Adjusted Major Ratio[c]
All Schools in Survey (23)	106.6	16.5	12.8	19.2	16.0
Co-ed. (9)	128	14.3	17.8	26.7	22.2
Male (10)	101	23.1	8.8	13.2	11.0
Female (4)	71	5.2	27.0	40.5	33.7

[a]Number of elementary geology students representing one potential major if majors are reported from the junior and senior years only.

[b]Number of elementary geology students representing one potential major if majors are reported from sophomore, junior, and senior years.

[c]An average based on the assumption that half of the schools reported majors from the junior and senior years only and half included sophomores.

The average number of instructors in these 23 college geology departments is just short of 3 (the range is from 1 to 5). There is no clear and regular increase in number of instructors from the schools with smaller enrollment to those with larger enrollment. It seems the day of the one-man department is on its way out, for only two of the schools surveyed are in this category. Several of the respondents cited the value of a multiple-instructor department from the point of view of both students and teachers. My own department is at present of the one-man type, but to insure my major students the opportunity of working under other geology teachers, as well as for other reasons, I require them to attend a summer field camp sponsored by another school. With the increase in general education courses in liberal arts colleges, and in view of the important part that geology should play in general education in science, the case for an increase in the number of geology instructors may be strengthened in some schools.

It is true that few, if any, geology teachers consider that their department lay-out is ideal, and in this regard the comments made by many of the respondents were most helpful. Floor plan as well as floor area is important, of course, but in the ultimate plan of buildings which house geology it is probable that many factors other than the teachers' wishes have dominated.

The floor area average from those reporting this item is nearly 6500 square feet (the range is 1700–15,000). This average is somewhat unrealistic, because some respondents included museum area and others did not. Again, no clear curve is to be noted from the schools with smaller enrollment to those with larger enrollment within the range of schools included in this survey. The "geology building" is uncommon, and the "science building" is becoming so. The common pattern is to include geology with one other department, generally a science department. Important, but hard for the architect to comprehend, is the need of all science departments for growing space. Perhaps this is especially true for geology, with its expansion into the fields of geophysics, seismology, structural chemistry, and, of course, with its faculty of inveterate collectors.

One or two elementary geology laboratories are, of course, essential in a liberal arts geology program. With elementary geology enrollments averaging more than 100, and in view of the desirability of restricting laboratory sections to 15 or 20 students, two laboratories for elementary classes may be needed, even in the smaller schools. The nature of the laboratory work required of students in geology demands that these rooms be very well lighted. Adequate storage space and display area should be provided in the elementary geology laboratory. If the class room for elementary geology is provided with tables rather than arm-type chairs (an arrangement considered most desirable by some geology teachers), this room may also be used for an elementary laboratory. In either case, it may be noted that the recitation room should have permanent projection equipment. A control panel should be provided at the instructor's desk for light switching, and with equipment now available it is possible to have remote control of window blinds and of slide changing.

It is essential that the geology lay-out include a minimum of two advanced geology laboratories. One can serve mineralogy, petrology, and, perhaps, optics; the other must serve paleontology, stratigraphy, economic geology, and perhaps other courses. Because of the nature of the work involved, these fields of study must have separate facilities. Nearly all the schools surveyed have this minimum of advanced laboratory space.

Other rooms considered essential by most of the respondents are map

room, dark room, storage rooms, and seminar room. The latter can sometimes house the department's maps and serve as the library room and can also be used for staff meetings. The cry of many of the respondents was, "Demand adequate storage space." The storage room can also be used as a preparation room and may perhaps contain lapidary equipment. If the storage room is located on the ground floor, an outside exit should be provided; if the storage room is on an upper floor, it should be located very near to the elevator.

A geology (or science) museum was included as part of the space devoted to geology in 70 per cent of the schools responding. The museum must be a teaching museum, with exhibits integrated with course work. The museum can aid community relations by serving grade-school and high-school science classes. If a museum is planned at the expense of laboratory space, obviously it should be argued against, for display cases can be erected in hallways, classrooms, and laboratories.

The case for a geology department library is very strong, but administrators and librarians will often fight against it. A vast number of geology publications can be listed as necessary laboratory equipment. Reports and maps of areal geology are essential in structural geology, stratigraphy, and petrology; fossil descriptions are needed in the paleontology laboratory; reports on ore camps are required in the teaching of economic geology; and mineral descriptions are helpful in mineralogy laboratory sessions. If publications of this type are housed within the geology lay-out they will be used many times more than if they are placed in the college library. Of the schools responding in this survey, 70 per cent have department libraries, a few others have geology in the same building as the science library, and the others list the lack of a geology library as a draw-back to their departments.

Other rooms that can be considered in the geology set-up are lapidary room, drafting room, office for the department secretary, and faculty research laboratories. The need for individual faculty offices should be stressed, and these should be large enough to provide table space for laying out maps. These offices should be close to the laboratories.

It is possible that a geology floor plan can contain too much space, but it is far more likely that insufficient space will be allocated to geology.

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TRAINING FOR A CAREER IN INDUSTRIAL MINERALS*

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Before we can talk intelligently about a career in the industrial mineral field and the preparation a man should have for such work, we must analyze the problem a bit. The nonmetallic mineral field covers not only a great many different minerals and rocks, but also several more or less distinct types of products. Also, the term "career" needs some defining.

If a man expects to enter government service or the teaching profession, the academic preparation needed is not the same as for a man who expects to hold an industrial position where the profit motive is essential. Furthermore, the training needed for a specialist, such as a spectroscopist or an analytical chemist, differs from that needed for a "generalist" or a man who hopes to become a producer or an executive in a producing company. The distinction is somewhat like that between a pure scientist and an industrial engineer.

In this age of extreme technical specialization, no man can hope to be highly proficient in more than one or, at best, a very few specialized subjects. We do not expect to find a man who is unusually proficient in optical mineralogy to be, at the same time, highly skilled in fine grinding techniques or in marketing problems.

Industrial minerals may be divided roughly into three general groups based upon mode of use. These are:

1. Minerals and rocks valued primarily for their physical properties, with the natural mineral structure largely unchanged in the end use. Examples are structural and ornamental stones, fillers, fibers, pigments, fuller's earth, molding sands, sheet mica, natural abrasives, and graphite. Chemical composition is important only as it affects such properties as weatherability or as it reveals impurities that will be injurious to the product in which the raw material may be used.

2. Minerals valued for their chemical composition and used as sources of elements or radicals. In this group the natural mineral properties are lost in processing. Examples are limestone used for chemical lime, for metallurgical fluxes, and

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for calcium carbide; cement raw materials; lithium minerals as sources of lithium chemicals; salt; fluorspar; phosphate rock; potash minerals; silica sands for glass melting and heavy chemicals. These are the raw materials for the industrial chemical industries.

3. Minerals used where both physical and chemical properties are important. Examples are ceramic clays; feldspar; quartzite or quartz for electrometallurgical use.

This classification is presented to demonstrate how impossible it is for a man to specialize either functionally, as an optical mineralogist for example, or by industry, say in the asbestos industry, and still have a well-rounded knowledge of problems in the industrial mineral field as a whole. Therefore, a student who thinks he wants to devote his career tc the industrial minerals should be given, early in his academic course, a bird's eye view of the field and what it involves in a general way. Generalized orientation courses which may serve this purpose are now sometimes given in the freshman year. The student should be made to realize very clearly the difference between specialization and a general knowledge of the field. If he wants to become a specialist he will neither need nor have time for many of the things which the generalist must study. On the other hand, the generalist need have only a superficial knowledge of specialized techniques and processes.

There are several reasons why the student will benefit greatly by an early, general review of the whole field and by a more generalized approach to his technical education.

Most young men, upon entering college, are too immature and inexperienced to know what field of work will eventually interest them most. If such a student begins to specialize too soon, he may find later that his chosen specialty doesn't interest him much. He may turn out to be a round peg in a square hole and be unable to afford the time or money to start in another specialty.

Temperament and aptitude play very important parts both in preparation for a career and in success and satisfaction in one's career in later life. Here, it seems to me, both the orientation course and the generalized approach, at least at the start, would help a man find his proper field.

Later in life, if the going gets tough, as it does with most of us at one time or another, the specialist may have a too narrow field of choice in which to seek new employment. The generalist, however, may know enough of several fields to enable him more readily to find a new job. After all, most companies have to train each new man to handle their own special problems, regardless of the specialized training the man may already have had.

Many years ago, the mining engineer was trained as a generalist. He had to know something about each of the other major engineering branches —civil, electrical, chemical, and mechanical—as well as the subjects peculiar to mining. In a number of schools the degree of mining engineer was a graduate degree. A bachelor's degree was required for entrance, and the whole period of training was usually six years. Today, with much more to be known, the tendency seems to be toward a four-year course and a high degree of specialization.

I still believe that the ideal arrangement is that of four years of generalization, followed by one to three years of specialization—the plan once followed by several of the most important universities with engineering departments. It is generally agreed that a year or two of practical experience, either just before or just after completing the generalized instruction, is of great value.

Technical and industrial progress certainly needs the specialist. But along with this specialization, we have a greater need than ever for the well-rounded generalist—a man who can see and understand the whole picture and can coordinate the work of the specialists.

In my work as a consulting engineer, I continually see examples of the lack of generalized knowledge and coordination. I see great waste, financial loss, and company failures due to misdirected efforts of specialists working beyond the borders of their knowledge and experience.

To illustrate how specialists may go wrong on subjects beyond their fields of experience, a single somewhat disguised actual example may be of interest. A highly competent consulting chemist, skilled in testing finely divided minerals, urged upon a client the building of a plant to produce mineral fillers, backing his judgment with some of his own money. The client knew nothing of geology or mineralogy and accepted the judgment of the chemist, who was similarly handicapped but didn't realize it. They believed there were "inexhaustible" reserves of their raw material. Didn't the geological map of the area show many square miles of the formation? Anyway, it was an old quarry, partially stripped, and "you could see there were millions of tons" available. They built a plant and started operations but before many months they were in trouble. They decided they should sell out to a better-financed producer. One of my clients became interested, and I took a look at the operation. The mill, with a few minor exceptions, looked good. But the deposit bothered me immediately. No detailed maps of the workings existed, and I brought in an experienced geologist to help me do a quick mapping job. We quickly found that joint planes had been taken for bedding planes, and the deposit did not go where they

thought it did. The amount of fairly good stone above water level was small. The water level of a pond, fed by a sizeable stream very close by, was at the quarry floor level, and evidence was strong that there were underground water channels and that any deeper workings would probably involve dewatering the pond. In addition, except for very limited zones, the available rock contained deleterious impurities which could not be removed economically. Incidently, my geologist assistant told me he never would have realized the economic significance of the factors which we disclosed. Working alone he would have been interested only in geologic structure, age, mode of origin, and similar features.

My report was negative. The owners were shown my report, and it took a good deal of explaining before they reluctantly admitted I was right. As far as I know, the property is still idle, although I believe another short-lived attempt was made to operate it.

Many similar examples could be given. Men trained or experienced only in specialized fields usually are not competent to pass judgment on other more generalized problems. The type of judgment needed to pass on many important problems involving policy can come only from generalized training and experience. But such judgments must often be based on the work of specialists. However, often only the generalist will realize when specialized know-how is needed, just where and how to get it, and how to use it. High-grade specialized talent is abundant in most fields, at least for short, specific jobs. But well-balanced, shrewd, over-all judgment is not so easy to find.

This defect in our present system has been noted repeatedly in recent years, but realization is not widespread as yet and it has not yet made much effect on our educational program. Educators, industrialists, and engineers are beginning to realize that the pendulum has swung too far in the direction of specialization and that we now need to train generalists. For example, a few months ago Francis J. Curtis, vice president of Monsanto Chemical Company, in an address before the Society of Chemical Industry at Nottingham, England, said there will be required "changes in our practices of scientific education [which] at present ... are mostly keyed to specialists. What we need is a new echelon of scientific generalists ... who will decompartmentalize science as it once was."

In the interests of generally raising standards in engineering education, the American Society for Engineering Education has recently proposed the division of engineering education into "professional-scientific" and "professional-general" education. (Again my division between specialists and generalists.) The ASEE president, L. F. Grinter, dean of the

Graduate School of the University of Florida, points out that four-year programs may not be sufficient to cover the needs of the professional-scientific group. For this group the Society recommends, among other things, increased background in mathematics, physics, and chemistry and a study of nine engineering sciences.

Another recommendation is a plea for more social studies and the humanities. With this I would agree only in part. It depends on just what is included in these groups, how they are taught, and how much time is to be devoted to them. If sociology, psychology, anthropology, and similar subjects are included, I am against it, unless a radically new approach is devised.

It is readily admitted that within the time limitations of a four-year or even a six-year course detailed instruction cannot be given in all of the subjects which would be useful in an industrial minerals career. But I do believe that something forceful and useful can be taught about most of the subjects of vital importance. In many cases I believe it is sufficient to impress upon a student that a problem exists, that it is essential that certain factors be noted and weighed, that certain types of testing can be done. But he doesn't have to know how to do all of these things himself. For example, in the production of mineral fillers, particle-size distribution tests may have to be made. The generalist should know the importance of such tests and where he can get them made by specialists, but it isn't necessary that he be able to make the tests himself.

I have a feeling that many precious hours of college time are needlessly wasted on teaching details to men who will never have any use for them. These hours could have been used in giving generalized instruction in wider fields. It is sometimes easier to give a series of courses on specific subjects like, say, saw-filing or glass-polishing, than to put a lot of meat into more generalized courses. The former type of course can be taught out of a book, while the latter requires a lot of experience and a lot of digging.

A common failing of many specialized types of engineers graduated today is that they have what has been called the "research approach." My own experience apparently parallels that of many others today. Recent graduates want to make "projects" of even the simplest problems. A brief quick study which could easily be done in a few hours is planned up into a five- or six-month project involving several men. The job is so over-engineered that the original objective is lost sight of. After hundreds of tests, elaborate calculations, showy displays of calculus, and scores of curves, an elaborate report is prepared which doesn't answer the question at all. A little imagination, a little common sense, and perhaps a few kitch-

en mechanic tests would have done a far better job. In a recent survey on this general problem one executive said, "We are getting too many young men whose narrow training fits them for nothing better than technicians' jobs ... Such a man can be valuable in a subordinate capacity, but he isn't going very far in the long run."

Specifically, then, what subjects should the student be taught to fit him for a generalized career in this field?

First, the basic subjects. This list is not intended to be complete but rather to emphasize certain subjects. Sound preparation in mathematics is essential. This should include arithmetic, algebra, plane and descriptive geometry, trigonometry, and probably calculus. Plane surveying is extremely useful in all branches of engineering and in geology. The ability to write and speak clear, logical English is also a necessity. The use of fancy, complicated structures and fifty-cent words should be sharply discouraged. The present tendency toward fussy, overly technical writing and obscure, highly specialized language is deplorable. It is found in every branch of science and engineering. Many technical papers today are almost unintelligible, not only to the average layman but also to fellow engineers and scientists. All technical papers and theses should be graded as strictly on English as on the technical content.

Recent technical graduates show the results of inadequate or improper training in the English language, not only by their use of unintelligible technical jargon and in their poor organization of material but also in their careless spelling, grammar, and sentence structure. The dean of one of our more important technical schools recently told me that many reports and theses offered for advanced degrees are written in deplorable English. He felt that he couldn't flunk a man because of poor English if his technical work was of good quality. Perhaps this is so, but I believe something drastic should be done to insure better preparation in secondary schools, required English courses in our technical schools, and the grading of all technical reports and theses on the quality of their English as well as on their technical content.

A man who cannot express himself well in the English language is badly handicapped in seeking advancement either as a technical specialist or as an executive. This applies not only to report writing but, with equal emphasis, to letter writing and to public speaking. How often do we get letters which are so poorly organized and so obscurely worded that they are ambiguous or wholly unintelligible. Only through the use of the written and spoken word can we pass on our thoughts and the results of our work. Language should be made a precise working tool. It should be clear, simple, brief, logical, and accurate.

Of the so-called cultural subjects, history is of great importance. At least a reading knowledge of two or more languages other than English should be acquired. A course in general economics is very valuable.

I doubt very much the value of including general or elementary courses in the social sciences, such as philosophy, psychology, sociology, and the like. The fundamental purpose is good, but as they are often given today such courses fail to achieve their purpose and they use up a lot of valuable time.

There is no question at all but that human relations are the most important phase of business life. No idea or process or plant is of any value unless some person or persons can be persuaded to do something about them. Academic life usually gives little or no warning of the pitfalls and frustations and double dealing and the general cussedness of human nature common to business life.

This is a hard subject to teach, but I sometimes think that a course in human business relations, taught by a panel of down-to-earth, hard-headed, practical business men would be many times as valuable as formal courses on abstract subjects. Such a course could be based on case histories, real or fictional, which would demonstrate forcefully that sheer ability and hard work often do not get their just rewards. I believe that the majority of young graduates sooner or later get up against bitter disillusionment, for which their academic training has not prepared them. Even among business executives there is far too much of a tendency to gloss over the real facts of life. Why not prepare a man a bit for his struggle with complacency, office politics, jealousies, ignorance, procrastination, influence, nepotism, and egotism? A man must learn that technical proficiency must often be mixed with liberal portions of human understanding and persuasiveness.

Next we should consider the instruction needed in technical subjects. Elementary chemistry and physics, of course, are essential today. More advanced courses are hardly necessary except for some specialists. Elementary geology and economic geology are likewise essential. The latter should be strongly slanted toward the nonmetallic minerals, instead of having the more usual emphasis on metallic ore deposits.

A comprehensive general course in mineralogy is of greatest importance, but it need not include much detailed work on crystallography or optical mineralogy except for the specialist. It should include, however, a general survey of mineral-testing methods, such as thermal analysis and particle-size determination.

The student should be given a brief survey of the more important methods of extracting minerals from the ground—that is, mining, quarrying, and dredging. Since the preparation of minerals for use is so closely tied in

with marketability of products, a course in mineral dressing and beneficiation should be given.

Marketing of minerals is an extensive and complicated subject, but it is of utmost importance. By marketing is not meant actual sales techniques, but rather the search for industrial uses and the adapting of mineral products to specific use requirements. This requires a knowledge of industrial processes. For example, in order to sell clay as a paper filler we must know just how clay is used in a paper plant and what use requirements must be met. Some of the mineral-using industries with which the student should have at least a nodding acquaintance are paper, paint, rubber, plastics, ceramics, and so on.

Mineral economics is a subject about which a specialist may perhaps need only limited knowledge. But if an engineer expects to work over the general field of industrial minerals, he must have a good grounding in this subject. The importance of marketing has been noted, but there are many other economic factors of great importance. Of these, perhaps "place value" is one of the most vital. Since many industrial minerals are of low unit value, transportation costs may be higher than all other costs combined. It isn't enough to know that you have a valuable mineral of good quality in adequate quantity with reasonable production costs. The most vital point may be that of location. Sometimes a relatively poor deposit close to a sizeable market is much more valuable than an excellent deposit in a remote locality.

For example, a deposit of sand and gravel, say on Staten Island in New York Harbor, accessible to barge transportation, may be a gold mine. But a deposit of building sand 60 miles from a railroad in Nevada, no matter how high the quality, is valueless. A deposit of rock from which coated roofing granules can be made, located near a prepared roofing plant, is valuable. A similar deposit 300 miles away may be valueless.

Practical experience, of course, is something which cannot be taught. But there is no substitute for it. Sound judgment comes only from experience. Men should be urged to get as wide and diversified experience as possible. In some large companies with many operations, this general experience can be obtained; but perhaps more often a few years with each of several different companies will give a wider diversification. Probably many industrialists will not like this advice to prospective employees. They dislike losing a man after they have invested in his training. Unless a man gets this diversified experience early in his career, he may never get it. As family obligations assume greater importance, security considerations may dim earlier goals.

This looks like a pretty formidable curriculum for a four-year or even a six-year course. It would be impractical if we were to try to give detailed courses in all of these subjects. But it is my belief that it is better to emphasize the basic courses, such as mathematics, English, and chemistry, and give brief, generalized courses on some of the other subjects, such as mining and mineral-dressing methods. Only a few highly specialized courses can be given in a four-year curriculum, and these may be of little value to a student later in life.

One preview critic of this paper feels that the curriculum outlined would not require four years, but could well be done in two. I have to disagree. Our difference may be due to viewpoint. I feel that a thorough job on this curriculum, which I cannot here discuss in detail, would require much more than four years.

The student should be told what subjects are important and how to go about getting further information on them, rather than be crammed full of details about a few of them, with the general field completely ignored.

Another critic says, "This points up an important consideration: the need for competent counsel and personal guidance based on the individual requirements of each technical student, if that is possible. This is another way of stressing the need for older, practical, ex-industry men as instructors in our universities today, men who can and would 'teach our kids to think for themselves.' "

To sum up, I believe the preparation for a career in the general industrial mineral field should include the following parts:

1. A sound general education with strong emphasis on English, mathematics, history, economics, and probably two foreign languages.
2. Basic courses in chemistry, physics, geology, and mineralogy.
3. General courses in mining methods, mineral beneficiation, industrial chemical processes, marketing, mineral economics.
4. Orientation and indoctrination on what the field covers and why.
5. Diversified experience in several industrial-mineral industries.

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A COURSE IN EARTH SCIENCE BASED ON STUDENT NEED*

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A previous report on a course in earth science at Muskingum College was made at the Columbus, Ohio, meeting of the American Association for the Advancement of Science (1939), in Section E's session on the teaching of geology and geography. The present report was written on the basis of more varied experience and more matured judgment.

Through the years a number of students in our general course who did not plan careers in geology questioned the value (to them) of some of the material they were required to master. At the same time I began to see that there were areas in earth science which they needed and which they were not getting. From there on I began to think in terms of values to the student rather than in terms of my former interest in the subject matter of geology.

Finally I devoted a class period to the discussion of the matter with the students. They expressed their viewpoints frankly. A group of six superior students volunteered to make a careful study of the problem. Each week, for the remaining three fourths of the year, we met for two hours to outline methods of carrying on the investigation and to evaluate the material brought in. Each student assumed the responsibility for investigating the needs that earth science might meet for different groups of non-geologists, such as lawyers, doctors, ministers and religious workers, business people, home makers, teachers, public-spirited citizens. Each student interviewed people actively engaged in such professions and occupations, recorded their viewpoints, and matured his own ideas. At the end of the year we organized our thinking and wrote a final report, which outlined topics that would be included in a general course.

In preparing the new course, I organized the following statement as a basis:

"The course breaks step with tradition in three respects. In the first place the idea of a *field* of knowledge, a conventional grouping of facts and principles, is repudiated. The course is built around certain related *focal points* of interest

*This paper was presented on April 10, 1953, at the first annual meeting of the East-Central Section of the Association of Geology Teachers, at the University of Cincinnati, Cincinnati, Ohio.

and no boundaries are recognized. Any material that naturally bears on these related points of interest is utilized without recognizing boundaries which are sometimes set up between earth science and economics, sociology, chemistry, art, physics, biology, religion, literature, music or any other conventional organization of subject matter. This, I hope, will tend to break down compartmentalization and encourage integration on the part of the student. I believe it induces functional unity. (The focal points themselves are all in the field of earth science.)

"The course breaks with tradition in a second way: no subject matter or principles are included solely because *custom* decrees it. The needs of the student determine the content of the course. The student is the ultimate consumer. No organization of subject matter is sacred if it does not serve the student. Consequently some things commonly included in courses in geology and geography are omitted from this course. Some things not included in the conventional course are included in this course.

"The third break with tradition is the introduction of the human interest approach. The aim is to take up problems in earth science vital to the student or to the society of which he is a member as focal points about which to organize the course. These problems are set forth as clearly as possible and are defined through class discussion. The student then seeks materials bearing on these problems and attempts to evaluate them. Later the student brings all this material into the class room where it is sifted and evaluated. Skill in finding and analyzing evidence, practice in scientific evaluation, and the drawing of conclusions and testing of their validity are developed. The degree to which this ideal is attained is one of the points requiring further study and evaluation."

Stated briefly, the objectives of the course should be to train the students to do the following:

1. To understand some of the more important facts concerning the Earth on which we live.
2. To understand the significance of these facts and the problems they present on local, national, and international levels of human life.
3. To find and read scientific literature, maps, and pertinent features of the Earth itself, in order to accumulate evidence needed in the solution of such problems.
4. To evaluate and use such evidence in solving problems and to estimate the degree to which solutions are reliable.
5. To appreciate our environment and literature, maps, pictures, lectures, and radio programs about it.

In the beginning the course met twice a week for discussion and once each week for a two-hour laboratory or field session. During the year we covered the subject matter of the traditional semester course in physical geology, the equivalent of elements of geography, and a taste of historical geology and historical geography. We used geology and geography texts

and library readings for source material. Interest was high and learning enthusiastic.

In evaluation we used a class in our regular four-hour year course in general geology as a control. We were able to pair a number of students in the two courses on the basis of ability, current grade point ratio, and sex. On the test items the students in the new course averaged significantly higher scores than their opposites in the general geology course and with less time devoted to the study of the material.

We realized then that we wanted our majors to have this experience. The geologist cannot live in a world apart. He needs to see the human significance of his chosen field. He needs to know the relationship of his own field with geography. He finds a knowledge of weather, climate, and life environments to be helpful in geology. Accordingly, our old general geology course is now an advanced course for students interested in geology. It follows earth science and fills a gap which formerly existed in our offerings. Since the student already has the equivalent of a semester of physical geology and a substantial introduction to earth history from the earth science course, he is now ready for a serious course in which problems and field work are important.

At present the earth science course carries four hours of credit, with three class sessions and one two-hour period for laboratory or field trips per week. During the first semester we find it convenient to use a text in physical geology as the chief source. We cover most of the topics in such a text except mineral resources and soils. We also get some understanding of those parts of the elements of geography included in geomorphology. During the second semester we complete the consideration of the elements of geography, such as weather, climate, soils. We consider the geology and geography of mineral resources.

We then make a regional study with greatest emphasis on the area surrounding the college. In this we study the stratigraphy and history of the local geology from field observation and extend this by study of U. S. Geological Survey folios as far west as Columbus, Ohio. In the east we get an idea of the Appalachian Mountains from other folios. We call on the students to observe and report on their home localities, which are rather broadly scattered as a rule. The study eventually leads into an examination of the history of the present physical and cultural landscape. We study the land-man relationships and trace the history of their development and try to see the problems man is facing as he lives in this environment. We try to keep the schedule flexible so that if the students want to we can spend an extra day on some subject, such as "The Roots of Mountains."

We think the advantages are several. By avoiding the overlapping of separate courses in physical geology and elements of geography, we seem to get the equivalent of at least a three-hour course each in physical geology, historical geology, elements of geography, and some applied geography, all in this one course. The work seems more real and vital to the student. He gets experience in applying what he learns. Students who have had this course are alert and problem-conscious when they take more advanced courses. The non-majors become intelligent consumers of earth science and use it.

The disadvantage is that the instructor and students must keep awake. Assignments must be worked out carefully and be well understood. Naming a chapter in a text is not sufficient. The instructor must have background in both geology and geography and an understanding of the philosophy of both fields. He must always be aware of the development of the student. He must keep his work oriented to life. He must be dynamic.

In the final analysis, "system" and course arrangement cannot take the place of dynamic presentation and sound scientific thinking on the part of the teacher. The course is what the teacher makes it.

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A VOLCANO MODEL

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As a result of a cooperative effort between the author and a number of education majors over a period of years, the volcano model here described has been evolved. The demonstration has been well received on the elementary and secondary school levels and has evoked considerable interest among geology majors. Its purpose is to depict a volcano in action, with its accompanying phenomena, through the use of the chemical compound ammonium dichromate. In the demonstration the ammonium dichromate is ignited to achieve the desired results, yielding nitrogen, water, and chromic oxide. The exact reaction is:

$$(NH_4)_2\,Cr_2O_7 \longrightarrow N_2 + 4H_2O + Cr_2O_3$$

Figure 1 illustrates the model constructed by the author for the demonstration. This particular design was found to be best after many other forms had been tried It can be constructed quickly, and the materials are quite common and cheap. The cone is composed of thin copper sheeting, which can be rolled by hand and cut with ordinary shears. The platform can be made of either composition or asbestos board but it should be fireproof. The leg stands are of ordinary wood. Actual dimensions of the model constructed by the author are shown. It has been found that this size is sufficient for small groups such as a single class. It may be necessary to increase the dimensions of the model proportionately when dealing with larger groups in a lecture hall. Dimensions of the platform and leg supports are not necessarily rigid.It is essential,

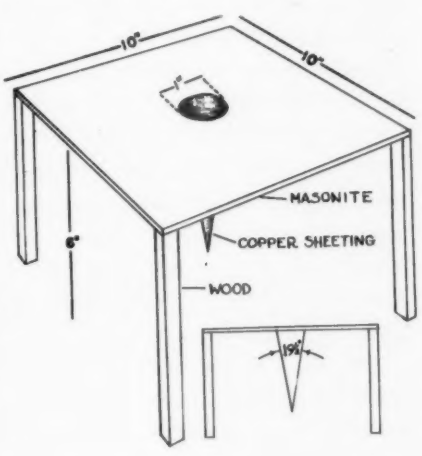

Fig. 1

however, that the shape of the cone taper to a point so that the walls form an angle as close as possible to 20°. This angle has been found to be rather critical for the successful operation of the model.

The ammonium dichromate should be in granular form, the ideal grain size being approximately that of coarse sand. Coarser crystals or fine powder may cause the demonstration to fail. Large crystals burn too quickly, owing to the rather loose packing. Fine powder, on the other hand, compacts too tightly to permit free burning. The chemical should be poured into the copper cone up to the level of the platform but should not be packed down.

There are a number of methods that may be employed in igniting the ammonium dichromate. Ordinary matches are generally not suitable, since the chemical requires a period of heating before ignition will take place. The author suggests that some sort of primer or fuse be used to quicken the lighting of the compound. Fresh magnesium ribbon, which burns at a sufficiently high temperature and which will assure proper ignition, is recommended for this purpose.

The author suggests that two demonstrations be shown to the group. The first, presented with the room in darkness, generally contains so much entertainment impact that the students will be eager for a repeat performance. The second run is then made with the lights on and can be used to point out certain characteristics and phenomena associated with the process of volcano building.

In the dark, the ammonium dichromate burns with a startling effect. Small incandescent fragments of chromic oxide are ejected, describing arcs as they fly through the air. The instructor should mention that these fragments are similar to the volcanic bombs which are thrown off by the actual volcano. At intervals the chromic oxide will cause clogging of the vent, thereby reducing the amount of material ejected and preventing free escape of the evolved gases. This results in a build-up of pressure, followed by occasional explosive eruptions. The process is repeated several times during the demonstration and is aided by the tapering shape of the copper cone. Initially a cylindrical form was used in this experiment. Because very little material slipped back into the cylinder, the ammonium dichromate burned steadily and there was little chance for gas accumulation. The concentration of debris in the tapering cone reaches a maximum in the last few moments of the experiment. At that time the gas pressure builds up to a maximum, resulting in a single large eruption which terminates the demonstration. Hissing and popping noises accompany each eruption and heighten the effect.

When the lights are turned on again, a steep-sided cinder-type cone, complete with crater, will be visible. The change in color (from the deep orange of the ammonium dichromate to the dark green of the chromic oxide) and the great volume increase of the oxidation product (chromic oxide) invariably surprise the spectators.

The discussion which follows this demonstration and precedes the second should stress several points:

(1) The material ejected is solid and is analogous to the material associated with a pyroclastic-type volcano.

(2) Because of the fragmental nature of the material steep slopes develop, a feature always characterizing a cinder cone found in the field. This feature develops in contradistinction to the relatively gentler slopes found on shield or composite volcanoes, which are built entirely or partially by liquid lava flows. A protractor with a plumb bob attached may be used to measure slope angles.

(3) The intermittent explosive eruptions of the model are quite similar to those occurring in an active volcano of this type. The cause is comparable in both cases—clogging of the vent followed by a build-up of gas pressure.

(4) The crater always forms directly above the vent, and the fragments are rather evenly distributed in all directions, forming a circular symmetrical mound.

(5) The poor packing of the chromic oxide is similar to the unconsolidated state of pyroclastic material in the field, particularly following an eruption. Slight jarring of the model will cause some of the fragments to roll down, demonstrating the poor packing, steep slope, and unconsolidated condition.

(6) At some distance from the base of the cone a thin layer of dust particles will be found, especially if a draft has been permitted to pass over the model. This can be compared to ash falls accompanying the eruptive phenomena in the field.

Ammonium dichromate is quite commonly used in chemistry lectures to illustrate a substance which decrepitates with an increase in volume. The use of this substance for this model has several limitations. It has been necessary to sacrifice several fundamental concepts of volcano building in order to achieve the above results. Consequently, there may be several misconceptions concerning this demonstration which should be corrected. The most glaring ones are:

(1) The platform is not necessarily analogous to the topography about a cinder cone, but is used to provide a convenient horizontal plane of reference.

(2) Vents do not taper to a point, as in the model, but are generally cylindrical in shape.

(3) Volcanic eruptions are not the result of the "burning" of magma or rock beneath the surface.

During the second demonstration of the model, the various features

represented may once again be pointed out as they are formed. It is preferable to have the students gather around the model, if possible, for a close-up view of the formation of the discussed features.

The author has no illusions that this model is the best possible for demonstrating volcano building. He hopes that this article will stimulate further work and thought on models in general and on this particular one. However, the experiment is entertaining and informative and does provide a useful teaching aid in the classroom.

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LABORATORY MAPPING

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Geology students are introduced to the spatial relationships of geologic bodies by diagrams, maps, and models which present those relationships in continuous geometry. Such two- or three-dimensional teaching aids are essential and cannot be dispensed with, but they have a major drawback in that they leave the student unprepared for the same geological relationships when they are met in the field as isolated points.

Experience indicates that although the student readily understands geologic bodies and structures when they are delineated by lines and surfaces, he is unable to make a synthesis of the scattered point outcrops usually encountered in field mapping. Fundamentally, this difficulty stems simply from his inability to group points with similar characteristics, and laboratory exercises may readily be designed to obviate this difficulty.

Considerable realism is possible for this stage of training, and the procedure outlined here has been followed with a good deal of success from the point of view of training and with much enthusiasm on the part of the students.

In essence, the laboratory exercises are arranged to simulate field conditions as far as practical. The student works on an accurately drawn floor plan of the laboratory—his base map—and locates and identifies specimens—the outcrops—which have been carefully placed by the instructor according to a prior plan. After the outcrops have been properly recorded on his base map the student interprets their pattern and completes his map with appropriate symbols, title, legend, etc. In general, it has been found most satisfactory to fix the location of specimens by a chalked ring, thus allowing them to be handled. Occasional problems require that one or more specimens be rigidly fixed in place to establish stratigraphic top, dip and strike, plunge, etc. (See figures.)

The general procedure for a complete exercise is as follows:

1. Prepare and reproduce in quantity an *accurate* floor plan of the laboratory, showing location (and height if desired) of all fixed furniture.
2. Sketch the desired geological problem on a plan.

3. Lay out appropriate specimens according to the geological sketch. Circle specimens with a chalked ring or fix them in plasticine.

4. Have students "map" the laboratory.

Typical simple mapping exercises are shown in the following figures.

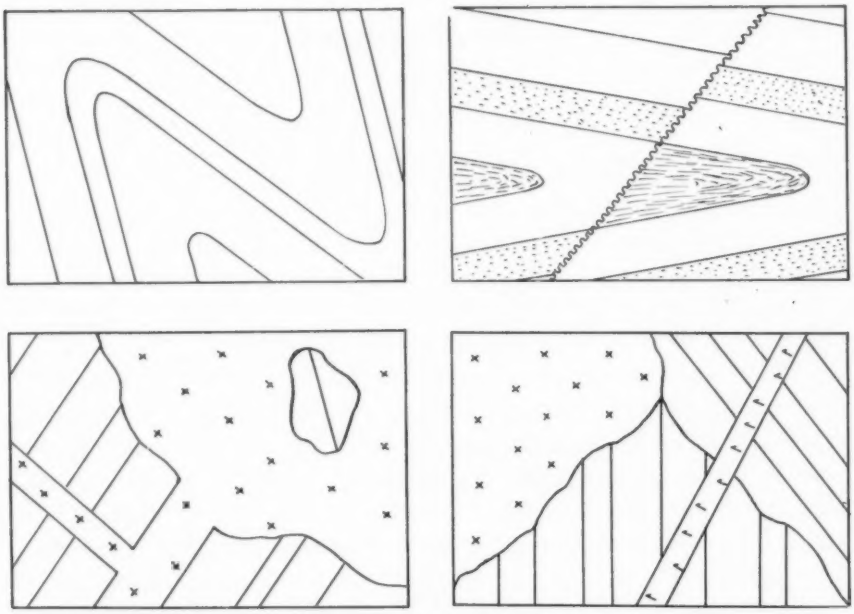

Fig. 1 (upper left)–Plunging folds. Use one fixed specimen to give stratigraphic top.
Fig. 2 (upper right)– Faulted fold.
Fig. 3 (lower left)– Igneous intrusion.
Fig. 4 (lower right)– A study in relative age.

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MODELS FOR INTRODUCING STRUCTURAL GEOLOGY*

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Wellesley College

It is essential to have simple, convincing models if one is to demonstrate the fundamental principles of structural geology in a laboratory for elementary geology. Wooden blocks with strata painted on the surface are unconvincing to students who have trouble visualizing the interrelationships between surface topography, outcrop pattern, and structure. In addition, wood is an unwieldy medium for illustrating folded structures, and it cannot be carved easily enough to show a variety of topographic forms simply and quickly.

For making simple models quickly and cheaply, styrofoam offers excellent possibilities. While this material pinches the wedge-shaped blade of a paring knife, it can be cut easily with an ordinary saw, a scroll saw, or a grapefruit knife. If curved surfaces are needed to demonstrate folds, the size of block that can be sawed is necessarily limited by the size of the scroll saw.

After a block has been sawed into the desired structural pattern, the parts can be cemented together again with plaster of Paris. This should be thin enough to spread very easily with an ordinary table knife but not so thin that it will drip uncontrollably over the edge of the block. It would be ideal if the strata could be colored; but common and cheap coloring agents are unsatisfactory, for some will not adhere to the styrofoam and others dissolve it. A satisfactory substitute is to color the planes of contact by adding a small amount of poster paint to the plaster of Paris. After the latter has set, topography can be carved on the surface with a saw, grapefruit knife, or saw-tipped paring knife. During the sawing there is some tendency for the colored plaster to drag, but when it is dry the most objectionable part of the smears can be brushed away.

After the topography has been carved, topographic contour lines may be added. Common pins inserted into the block guide a thread to the desired position, and the thread ends are wound around the block and tied. The contour threads can be held in place by Duco cement applied with a

*Presented on April 3, 1954, at the second annual meeting of the New England Section of the Association of Geology Teachers, held at the University of Vermont at Burlington.

pin at critical points, such as at corners or in the middle of long stretches, and the pins can then be removed. Use only a small amount of the cement, because it dissolves the styrofoam and if used in excess it produces ugly pits. If valleys have been cut into the edges of the block so that contours end at the block boundaries, it is simplest to use a continuous

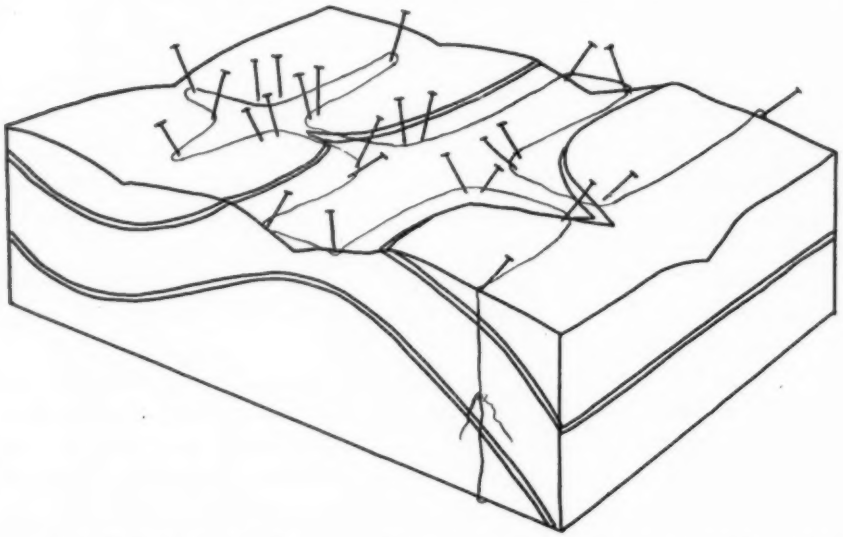

Fig. 1—Block showing folded structure, with a contour thread pinned in place and tied around the block ready to be cemented. Parts suspended across valleys are to be removed later.

thread for each elevation, suspending it across the valleys at the edges of the block (see Fig. 1) and clipping the unwanted part away after the thread has been cemented in place.

A very useful block to demonstrate the relation of structure contours to topographic contours can be made provided the structure is limited to uniformly dipping strata or simple folds in which the direction of the structure contour line does not change within the area of the block (see Fig. 2). The block is sawed into the desired parts. Structure contours— heavy strings well coated with vaseline—are then added along one of the structure planes and held in place by pins on the sides of the block. The pins must be placed so that they will not interfere when the next part of the block, coated with an eighth of an inch of plaster of Paris, is pressed into place. When the plaster has set the strings can be pulled out, topography can be cut into the block, and thin, straight wires—obtainable from florists—can be run into the holes left by the strings. If the wires are long enough to protrude beyond the edge of the block the student can see clearly

the position of structure contours, running under hills and suspended across valleys. If the block is accompanied by a map of itself it is possible to show clearly the relation of structure contours, topographic contours, and geologic map, as represented on a flat surface.

Styrofoam can be purchased in quantity from local offices of the Dow Chemical Company or from wholesale florist supply houses, which will

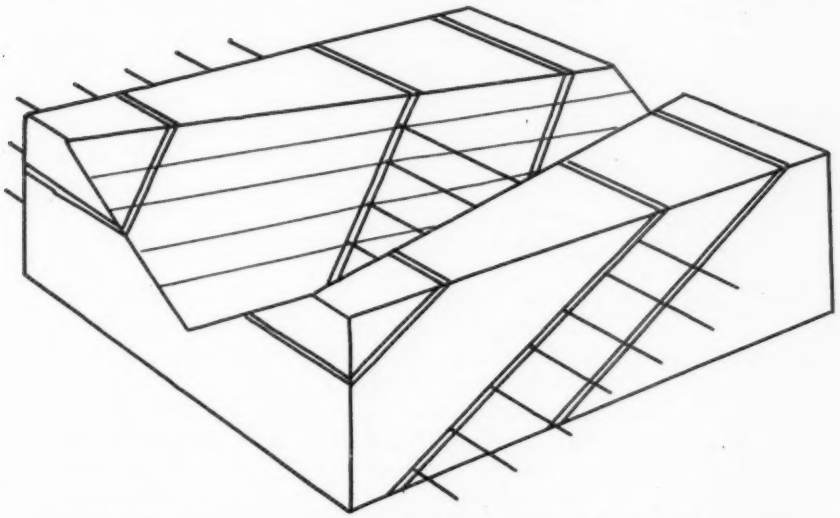

Fig. 2—Block showing uniformly dipping strata cut by a simple valley. Both topographic and structure contours are represented.

sell small quantities to educational institutions. Sheets 36 by 12 by 2 inches purchased from them cost less than $1.50. Styrofoam can also be obtained at retail prices from garden shops and florists, and at Christmas time in ten-cent stores. Blocks of convenient size cost about 15 to 20 cents each.

In addition to styrofoam and excluding a common saw the cost of equipment needed for all types of blocks is under $2.50. This includes the permanent items (scroll saw, grapefruit knife or saw-tipped paring knife, and table knife for plastering) and enough of the expendable materials (poster paint, plaster of Paris, pins, thread, Duco cement, string, straight wires, vaseline) for many blocks.

BOOK REVIEWS

Minnesota's Rocks and Waters. George M. Schwartz and George A. Thiel. xx and 366 pp. (Minnesota Geological Survey Bulletin 37). The University of Minnesota Press, Minneapolis, 1954. $4.00.

For many reasons the American people are becoming increasingly aware of their inescapable dependence upon the earth's resources in this age of rapid technological progress. Whether or not they are employed in any of the extractive industries engaged in procuring metals, mineral fuels or other non-metallic minerals from the earth, they are learning something about the problems that result from the geographic distribution of the limited and non-renewable sources of industrial prosperity. Whether or not they themselves till the ground, they have been hearing much about soil erosion and soil conservation. The rocks and soils and waters of any country are now widely recognized as the foundation of its inhabitants' well-being, the hope of their future. America is coming of age in these years of our lives.

This is a sufficient reason for the writing of such a book as this. How much greater would be the interest of millions of citizens in their work if they understood the geological origins, conditions and relationships of the materials with which they labor! But there is another reason which for many may have even greater force. One may admire the scenery of mountains or of plains, the beauty of a waterfall or a wave-beat headland, but to appreciate fully one's natural surroundings, one must know something of the processes that formed them. In these days of unprecendented opportunity for travel, an understanding of geology becomes a well-nigh universal desire. For the majority of Americans, its aesthetic values and intellectual satisfactions transcend its utilitarian services.

True it is that this book deals specifically with the geological features of only one of the forty-eight states. It is, however, a state with a large population, with unusual mineral resources, and with notable attraction for tourists, especially in the summer months. Moreover, it happens to be located close to the center of the continent and in its geology it epitomizes the results of almost every geological process that has ever been operative anywhere. To know and understand the geology of Minnesota is quite sufficient preparation for an enriching appreciation of the landscapes and rocks of at least the northeastern quarter of the United States.

Drs. Schwartz and Thiel have attained their objectives with great skill. The former is director of the Minnesota Geological Survey; the latter, chairman of the Department of Geology in the University of Minnesota. They have held technical terms "to a minimum in order to make the text intelligible to those unfamiliar with detailed geological terminology." They make their science come alive with all its fascination for those who are curious to learn "how the world was made" and with much of its significant values.

The book is in two parts. First there is an excellent introduction to geological materials and processes, followed by a chronological account of the history of Minnesota from the time of origin of its ancient pre-Cambrian rocks to the close of the "Great Ice Age," ten thousand years ago. The final chapter in this part

describes concisely the state's mineral resources, ranging from iron ores to glacial clays. Part 2 consists of seven chapters, descriptive of "geological excursions" throughout the state. These pinpoint for the local residents and visitors the features of interest for interpretation and appreciation.

The book sets a high standard, both in its smoothly flowing text and its wealth of fine photographs and diagrams. The time is ripe for several other regional treatments, in this excellent pattern, by other geologists competent to do a similar thing for the states and areas with which they are familiar.

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(The above review is reprinted, with permission, from the Phi Beta Kappa news magazine, *The Key Reporter*, Vol. 19, No. 4, September 1954.)

Principles of Geomorphology. William D. Thornbury. ix and 618 pp. John Wiley & Sons, Inc., New York, 1954. $8.00.

It is undoubtedly true that Thornbury's *Principles of Geomorphology* is the textbook many teachers of geomorphology have been looking and waiting for. It is a book pitched at a considerably higher level than any one of the texts which appeared in rapid succession about 15 years ago and which disappointed many teachers because they failed to carry the student far enough beyond the level achieved in a well-taught physical geology course.

The emphasis in Thornbury's book is on the landscape-shaping processes—as the author says, "complex factors which have influenced their [the landscapes'] evolution"—and not upon classification of landforms in and of itself. The author states his intent to examine concepts critically, and to a degree this intent has been carried out. By "critical examination" the author seems frequently to mean the presentation of both sides of a controversy without particular comment. The fairness of the textbook is illustrated by the way in which the Davis-Penck controversy is handled. The problem is presented in a thought-provoking rather than a dogmatic fashion, and students and professor alike should be challenged to make a united assault on the thorny problems associated with slope retreat under weathering and erosion attack.

The fairness of Thornbury's presentation is illustrated also by the section devoted to the geomorphology of coasts. Here the Johnson-Shepard differences are presented without special intrusion by the author of the text. This reviewer welcomes this type of presentation because of its value for teaching. About when undergraduates take a course in geomorphology, the time has come for them to learn once and for all that not all problems have been solved and that much disagreement exists and much work remains to be done.

A very welcome chapter in the text is the one on topography of ocean floors. Its inclusion is fitting considering the large amount of research accomplished in recent years in the field of submarine geology.

One of Thornbury's firm and stated purposes in writing this book was to emphasize the practical aspects of geomorphology. This emphasis comes most thor-

oughly in a final chapter entitled "Applied Geomorphology." The emphasis on the usefulness of geomorphology is welcome, but one wonders if the author has not gone too far in his attempt to prove that geomorphologists too are practical. A scientist must avoid being maneuvered into a position of having to justify his study on the basis of its practicality. Complete understanding and joyous appreciation of the entire history of landscapes, worked out step by step, must always be the goal of the geomorphologist. He must not expect nor particularly desire to enter the field of "practical geology" except as a consultant; at such times his broad understanding of landscape-shaping processes should enable him to be of help to his much more narrowly interested colleagues.

Thornbury's text will undoubtedly disappoint many who are absorbed in the "new" geomorphology—the geomorphology which is emerging from the laboratories and the computing machine rooms, the geomorphology of the hydrologist, the meteorologist, the river engineer, the soil mechanics expert, in short, the geophysicist! Thornbury of course recognizes the development of "quantitative geomorphology" but dismisses it with faint praise. The quotation which he includes from the writings of Baulig might better have been omitted because it seems particularly unscientific and dogmatic. How may one say that "the laws of geomorphology are complex, relative, and rarely susceptible of numerical expression" when so little attempt has been made (until recently) to really discover by experiment or measurement or by statistical analysis whether the laws of geomorphology *are* or *are not* susceptible of numerical expression? We certainly must beware of the quicksands of defeatism. This reviewer joins with the author in his hope that a knowledge of mathematics, physics, and chemistry will never become *most* essential to an understanding of geomorphic discussions. However, geomorphologists must try always to be scientists, and a scientist does not turn his back on tools and techniques offered by other scientists to help him solve his problems and answer his questions.

Thornbury's text may well be the last in its genetic line, the final member of the family of descriptive or qualitative texts. The logical next need in geomorphology is for a volume which will "textbookize" the abundance of quantitative data, generalize and summarize the work so far accomplished in the laboratories, and treat adequately the quantitative techniques which are currently an exciting development in the field of geomorphology.

Current textbooks tend to be wonderfully well illustrated, and the book under discussion is no exception. Since the book is published by Wiley, as was Arthur N. Strahler's recent *Physical Geography*, many of the admirable diagrams from that text have been used. Certain of the other diagrams are not up to this high standard, particularly the one which so greatly exaggerates the natural levees of the Mississippi and which seems to show the streams developed on the levee flowing the wrong way. Many fresh and excellent aerial views are included, and other pictures are also fresh and well selected. The reviewer notes that the fancy "bleeding margin" half-tones so much in style in the near past have not been used. Does this mean the end of a fad which was not worth the extra cost in the first place? One hopes that any saving in production costs which may have resulted can be passed on to the student who purchases this book.

Thornbury has put together a balanced and teachable text which will undoubt-

edly be widely used. It is a book students of geology, no matter what their specialty, will want to add to their personal libraries.

RICHARD H. MAHARD

Denison University

NOTES AND NEWS

ANNUAL MEETING OF THE ASSOCIATION. On January 28-29, 1955, the Association of Geology Teachers and the East Central Section of the Association will hold their annual meetings, in joint session, at Columbus, Ohio, as guests of the geology department of Ohio State University. The meetings will feature a tour through the multi-million-dollar research quarters of Batelle Memorial Institute, which employs a large staff of geologists; a symposium on "Geology on TV"; a film and symposium on "Increasing College Enrollments: What Will They Mean to Geology"; a slide symposium; and exhibits of teaching aids. At the banquet on January 28 the Neil A. Miner Award for 1954 "for exceptional contribution to the stimulation of interest in the Earth Sciences" and the Honorary Membership Award will be presented, and Leland Horberg, retiring national president of A.G.T., will deliver an address. There will be short business meetings of the national organization and of the East Central Section.

NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE. On Saturday and Sunday, October 9-10, the New England Conference was held at Dartmouth College, Hanover, New Hampshire. The field trips offered, and their leaders, were as follows:

Glacial geology of the Hanover region—E. D. Elston and A. L. Washburn.

Structural geology of the Hanover region—J. B. Lyons.

Economic geology of the Elizabeth Mine, South Strafford, Vermont—H. E. McKinstry.

Geology and mineralogy of the Ruggles Mine, Grafton, New Hampshire—A. H. McNair.

Structural geology of the Skitchewaug Mountain area, Claremont quadrangle, New Hampshire-Vermont—J. B. Thompson.

Geology of Ascutney Mountain, Claremont quadrangle—R. E. Stoiber.

EARTH SCIENCE CONFERENCE. The Second Annual Earth Science Conference for teachers, sponsored by the Departments of Geography and Geology at Bowling Green State University, was held at Bowling Green, Ohio, on October 9, 1954. About 80 persons attended. In both morning and afternoon sessions papers bearing on the teaching of earth science subjects were presented. Teaching aids and materials—texts, maps and charts, other visual aids, mineral displays, student collections and projects, etc.—were placed on exhibit by commercial concerns, the Office of the State Geologist, the State Department of Conservation, the Departments of Geology and Geography of the host institution, other teachers and students, and the Rock Circus, a privately operated non-profit museum. Here is a practical way in which members of A.G.T. can help to strengthen the position of the earth sciences in the elementary and secondary schools. Are there similar undertakings in other areas? Let us hear about them.

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